

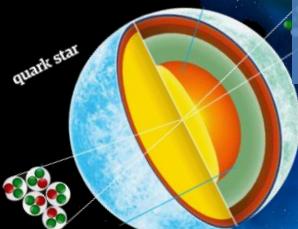


Black Hole Ergosphere

Search for Strange Quark Matter from the ISS with the ISS-SQM experiment

Quark star collision

*F. Bisconti, M. Casolino, A. Drago, L. Marcelli,
Z. Plebaniak, C. Fuglesang, E. Parizot*



Big Bang cosmology

Strange Quark Matter

SQM-ISS

20/06/2023

Strange quark matter, strangelets etc...

Quark stars?

Core of neutron stars?

Models with a strong phase transition: two-families
of compact stars

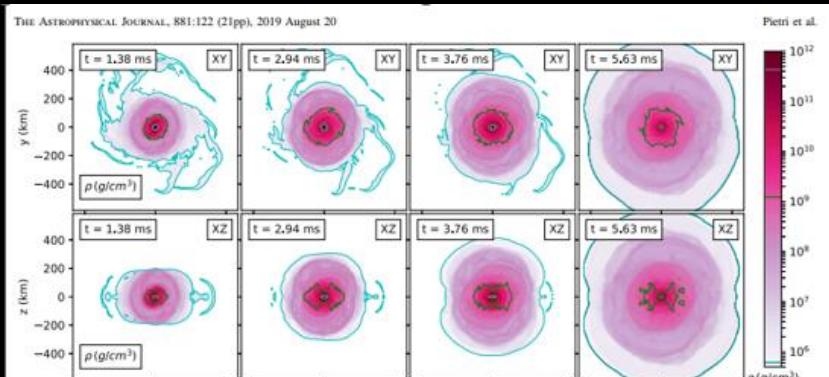
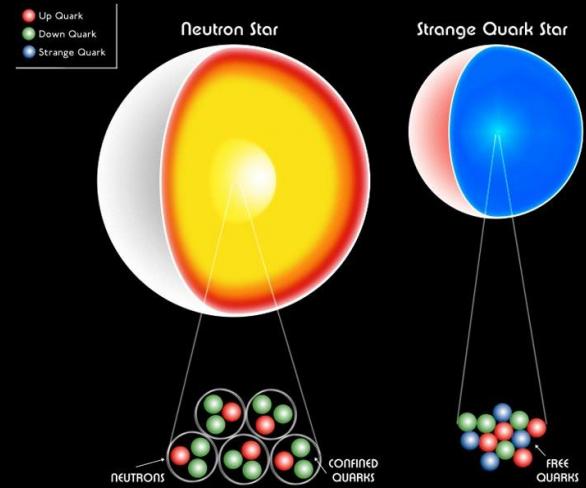
Stars made of hadrons co-exist with stars made of
strange quark matter

A. Drago, A. Lavagno, G. Pagliara, PRD 89
(2014)143014

G. Wiktorowicz, A. Drago, G. Pagliara, S. Popov;
Astrophys. J. 846 (2017) 163

Cosmological origin?

Fragments could be present in the galaxy,



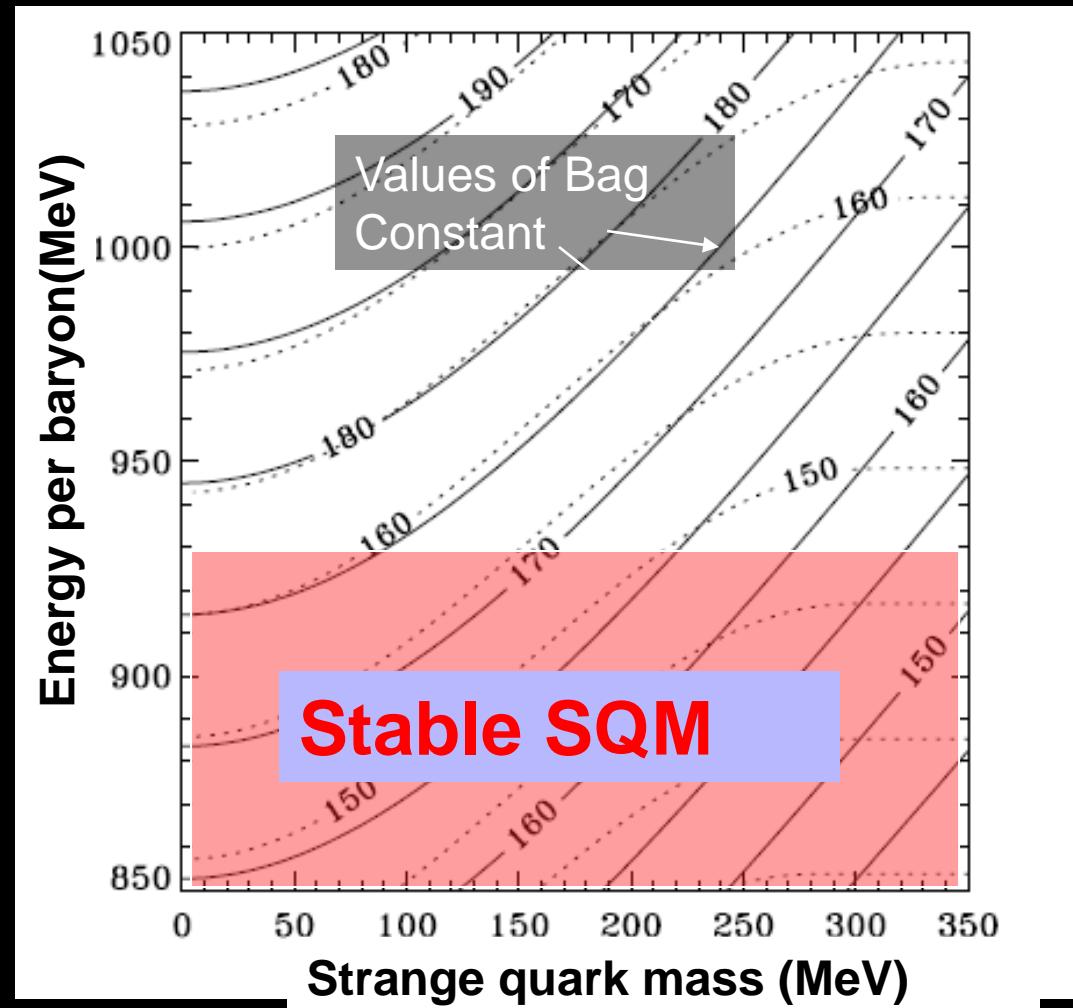
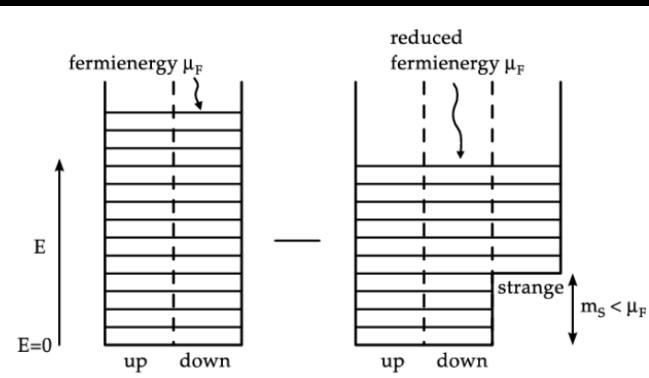
Burdin et al., Non-collider searches for stable massive particles, Physics Reports 582, 2015

N. Bucciantini, A. Drago, G. Pagliara, S. Traversi and A. Bauswein, 1908.02501.

No new physics required

Lower Fermi energy level per nucleon with uds levels

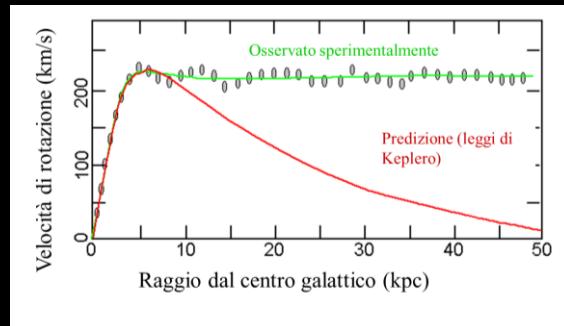
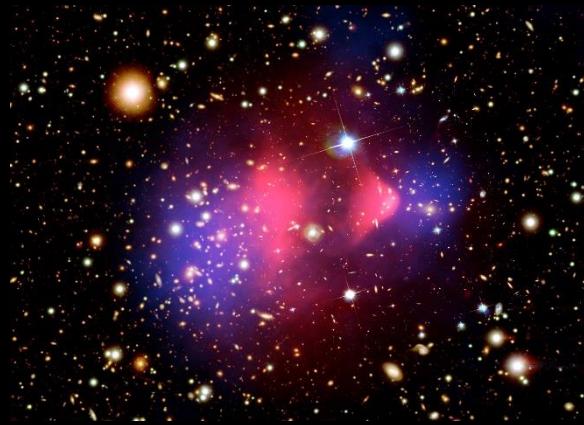
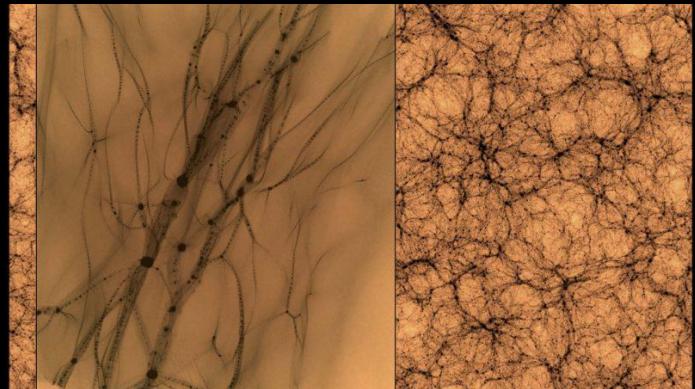
Candidate of DM
(Witten 1984) / barionic but denser, so ‘fluid mechanics’ is different → e.g. bullet cluster



SQM as a Dark Matter Candidate

Barionic constraints do not apply (denser matter) in formation of structures in Big Bang Cosmology

Also bullet Cluster-like ok



SQM / Macro search

Direct (live)
Pamela
SQM-ISS

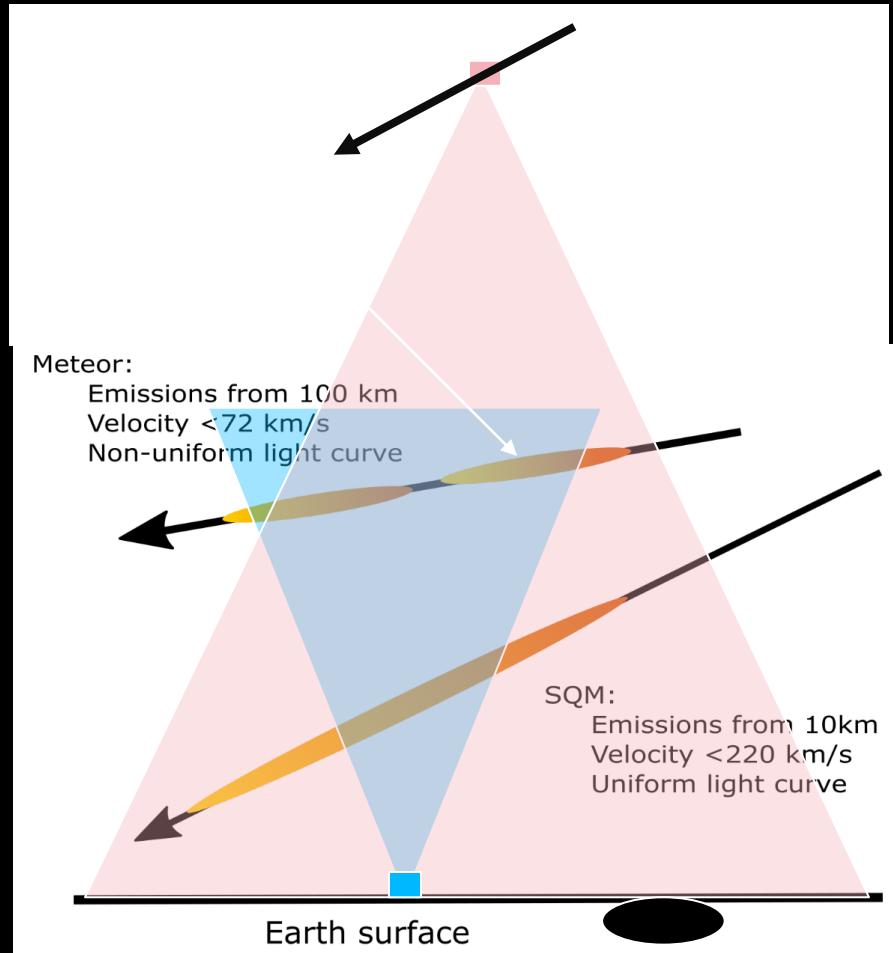
Atmosphere → See talk by L. Marcelli

SQM brightness $\sim v^3$

Signal deposited in pixel $\sim \frac{1}{t} = \frac{1}{v}$

Detection efficiency $\sim v^2$

Direct (“dead / dying ”)
Moon soil
Earth soil
Mica Tracks
Impact craters
Seismometers

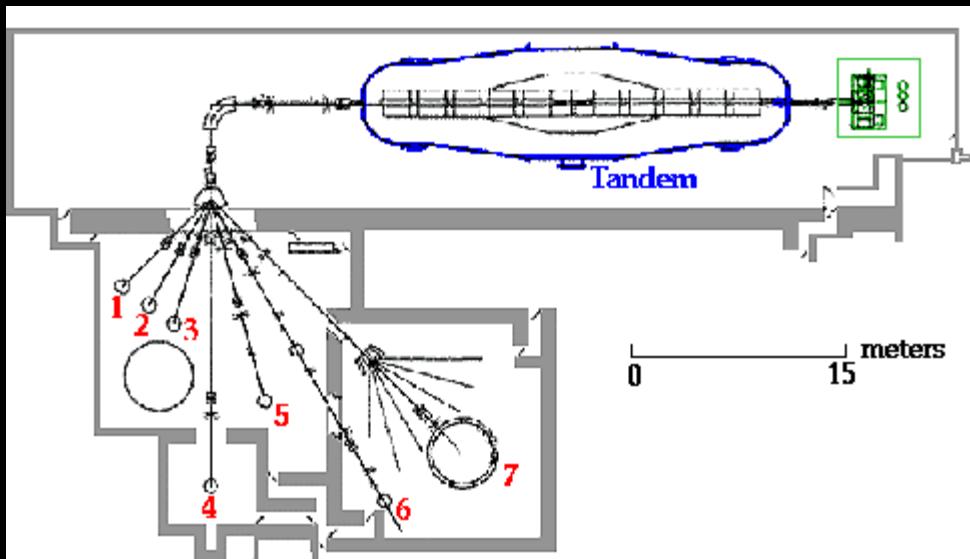
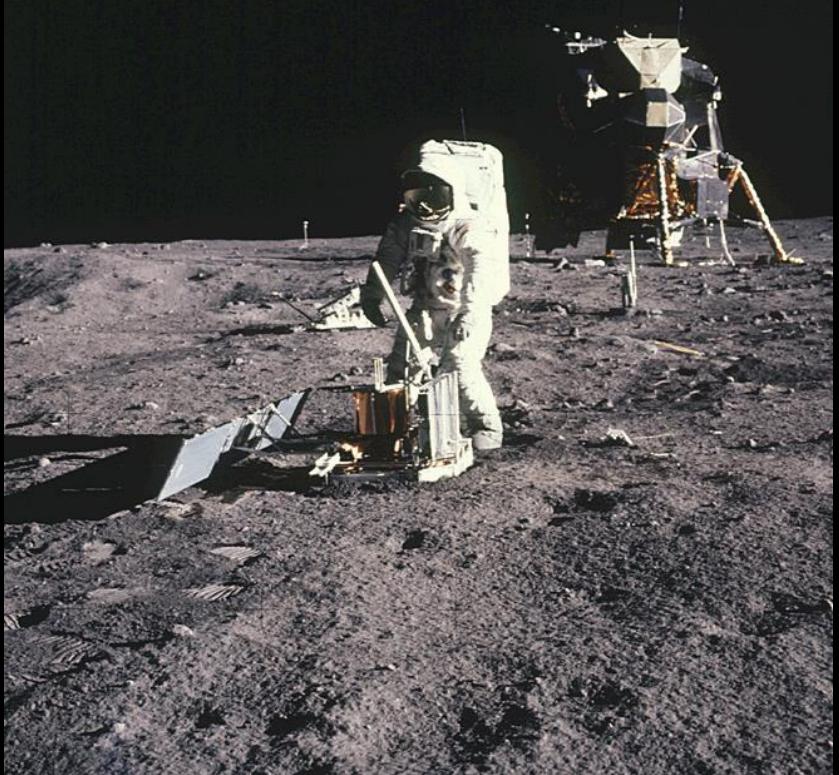


*De Rújula, A., Glashow, S., Nuclearites—a novel form of cosmic radiation,
Nature 312, 734–737 (1984).*

Witten, Cosmic separation of phases. Phys. Rev. D 30, 272, 1984

Ground, Moon Dust, Apollo Moon seismometers

Apollo seismometers, 28 events
Nakamura, Frohlich (2006)



PAMELA

Strangelet upper limit

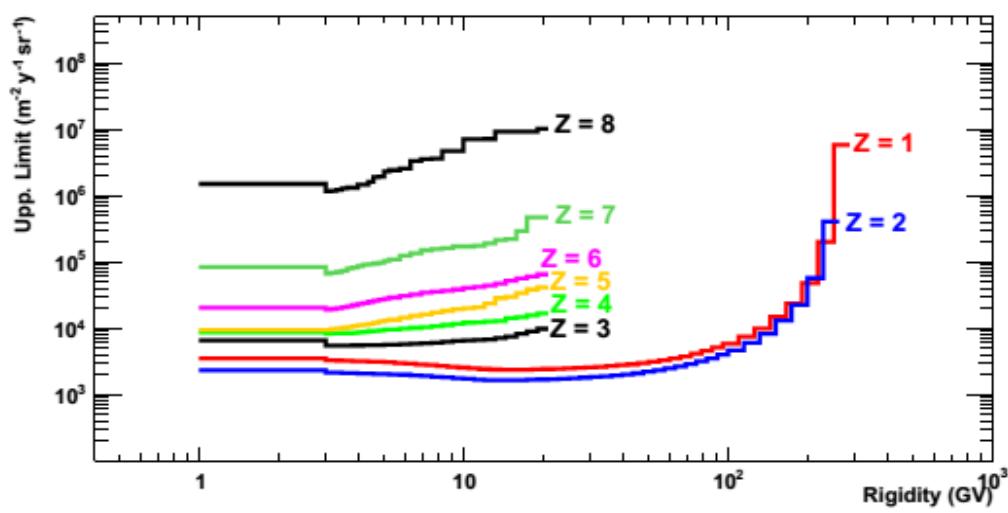
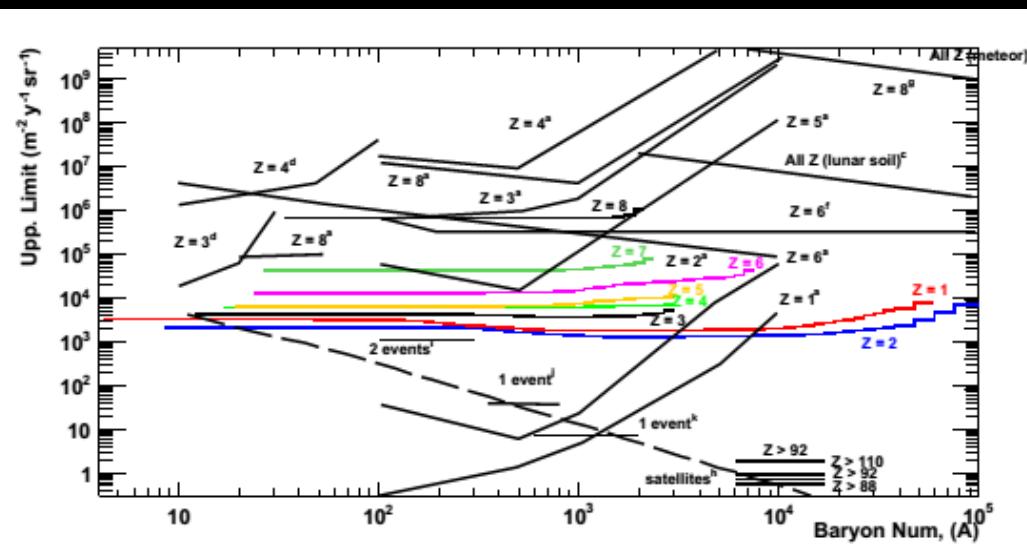
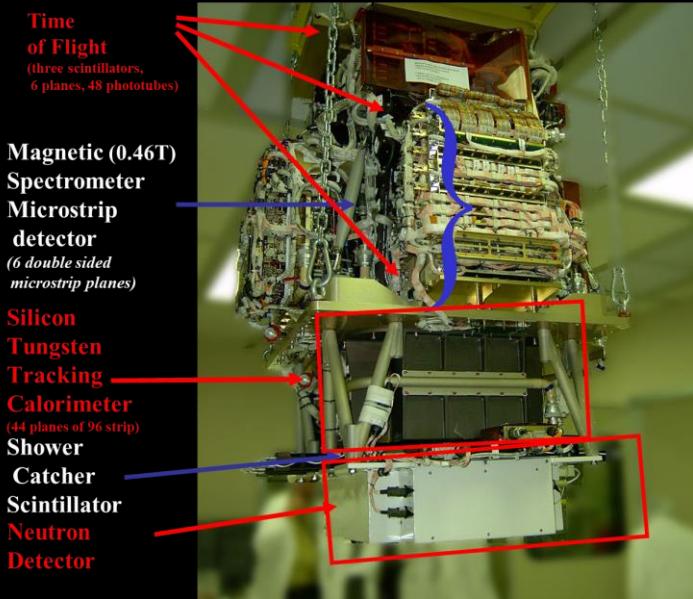


FIG. 4. Integral upper limit in terms of rigidity, as measured by PAMELA, for nuclei up to $Z=8$.

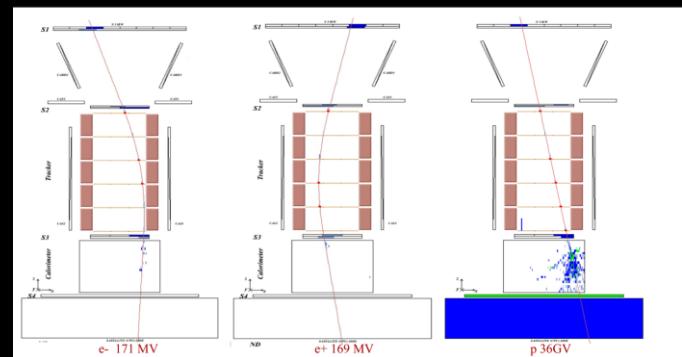


The detector

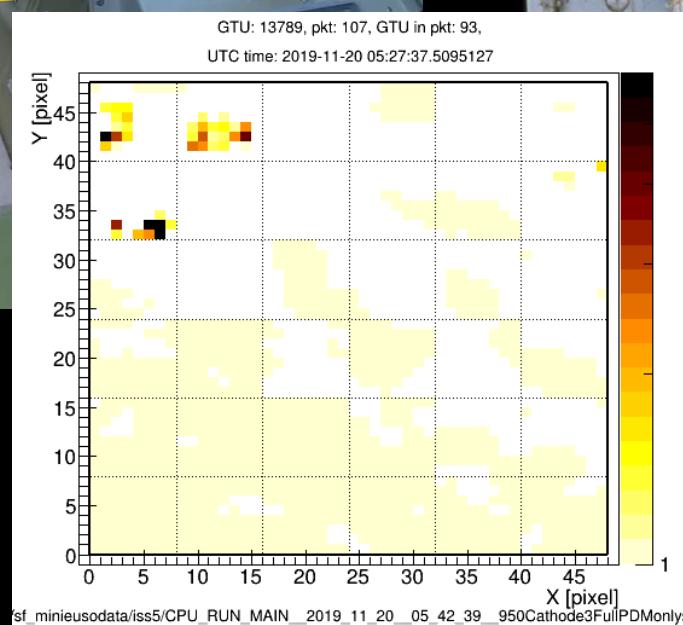
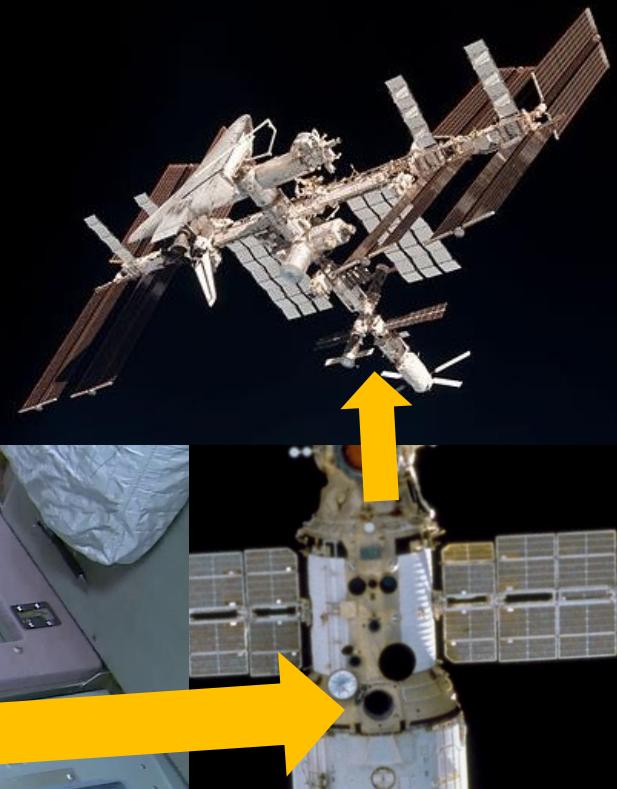
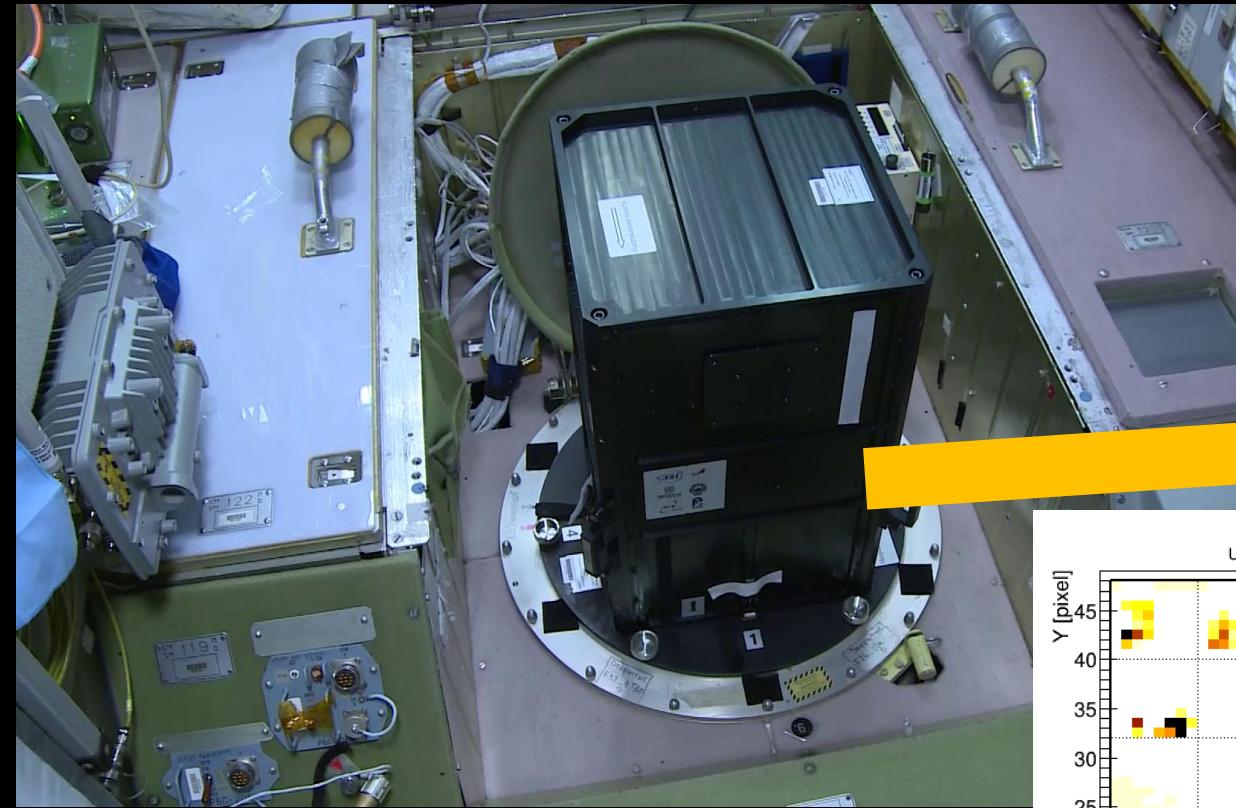


Principle of detection

Electrons Positrons Protons



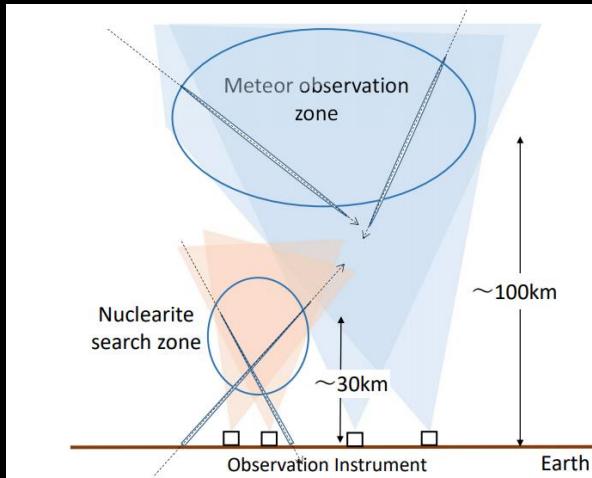
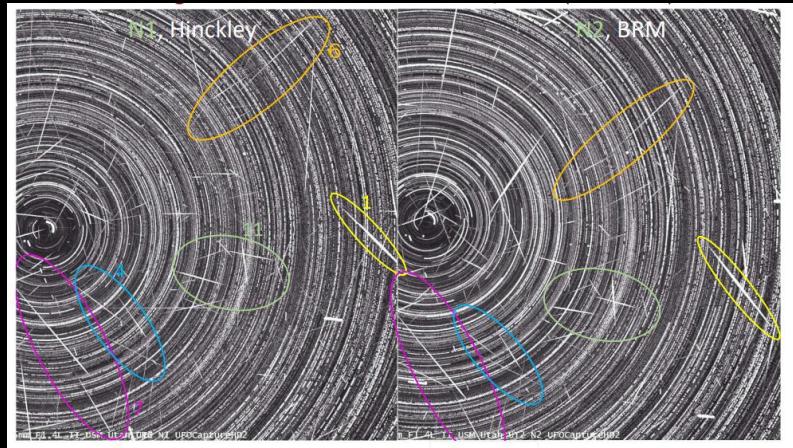
MINI-EUSO 2019- International Space Station



Meteor studies in the framework of the JEM-EUSO program. PLANETARY AND SPACE SCIENCE, 143(SI):245{255, SEP 1 2017.

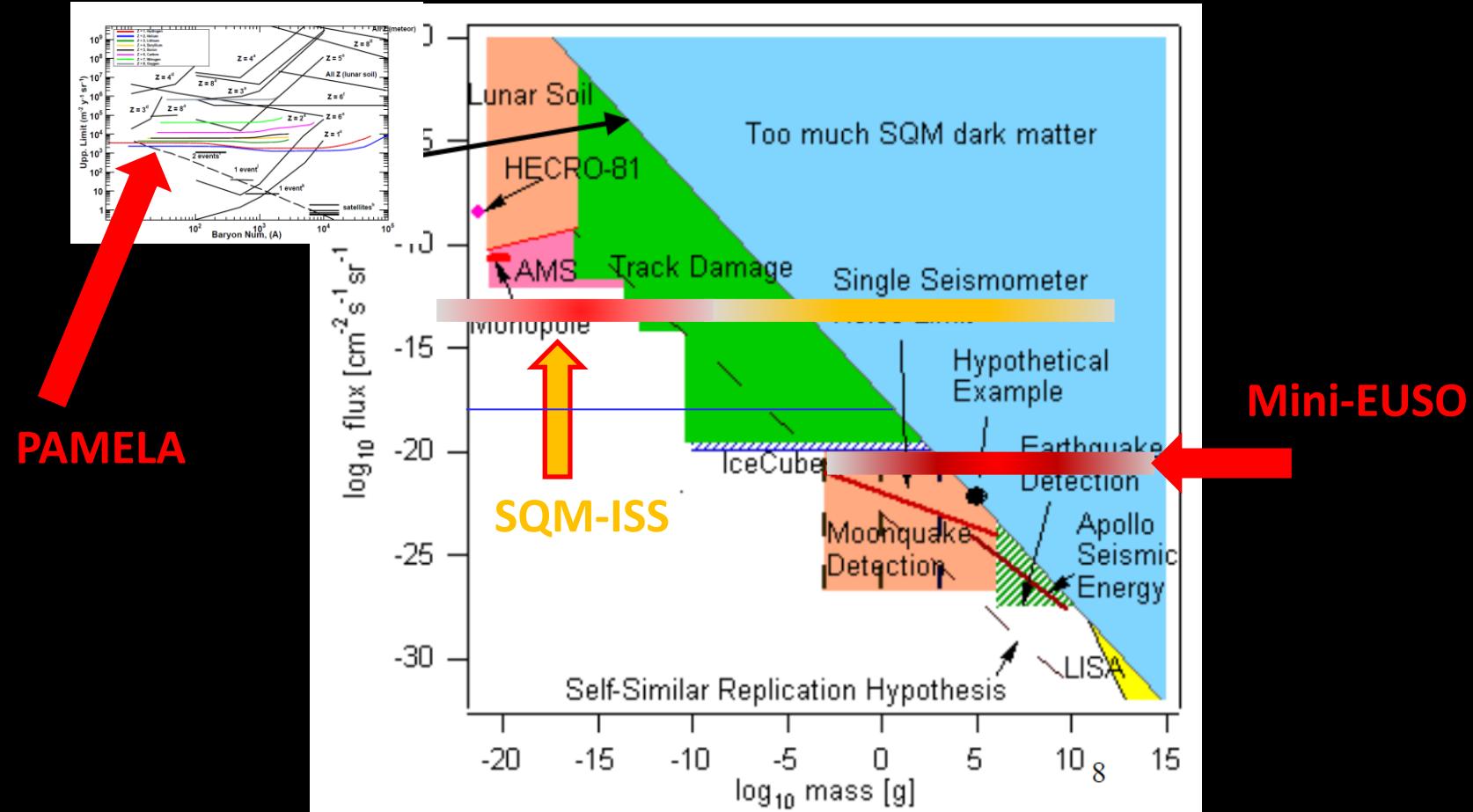
JEM-EUSO: Meteor and nuclearite observations. Experimental Astronomy, 40:253{279, November 2015.

DIMS (F. Kajino, Konan Univ.)

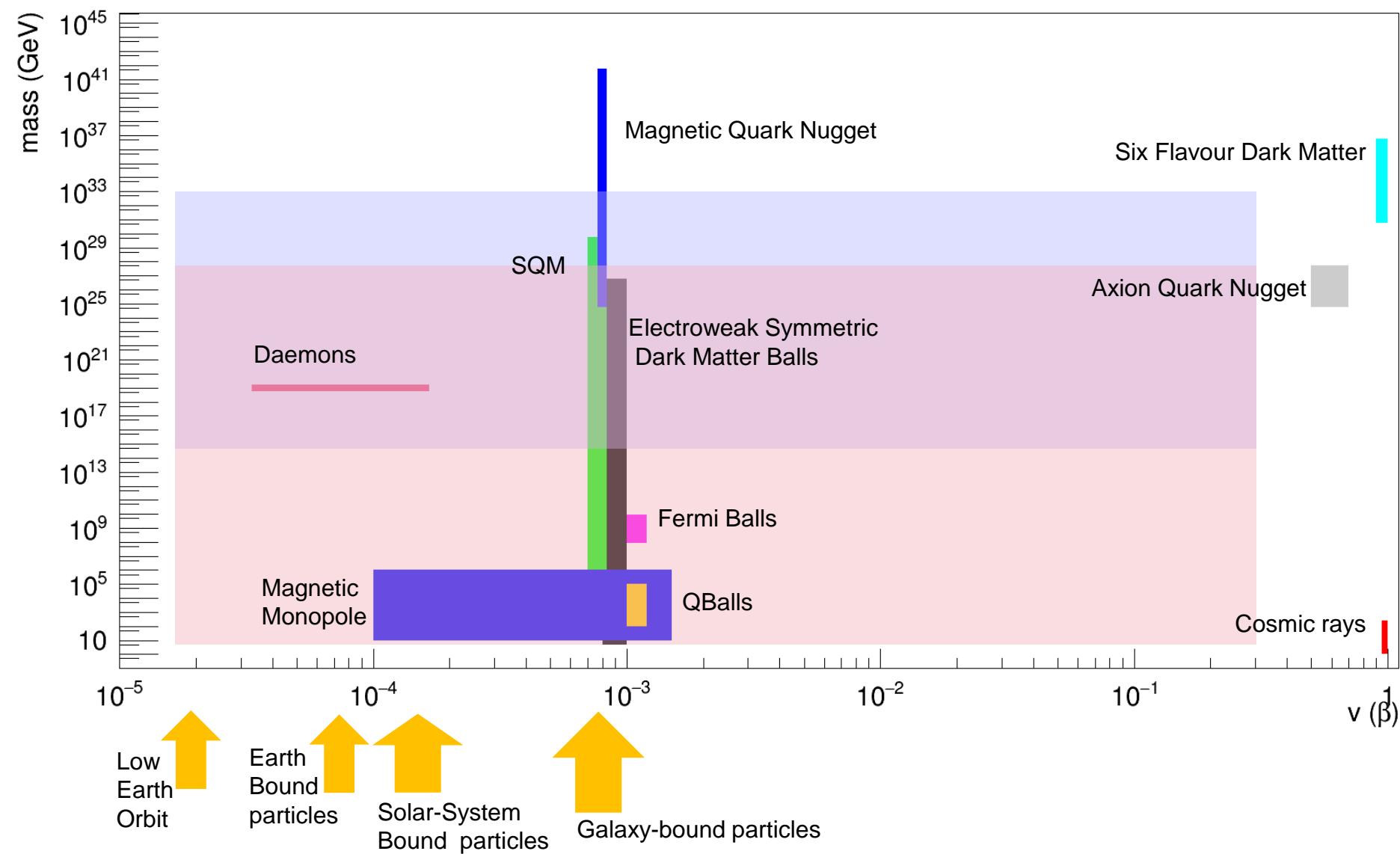


SQM-ISS

Expected upper limit for three years of operations



Slow, Heavy Massive particle candidates

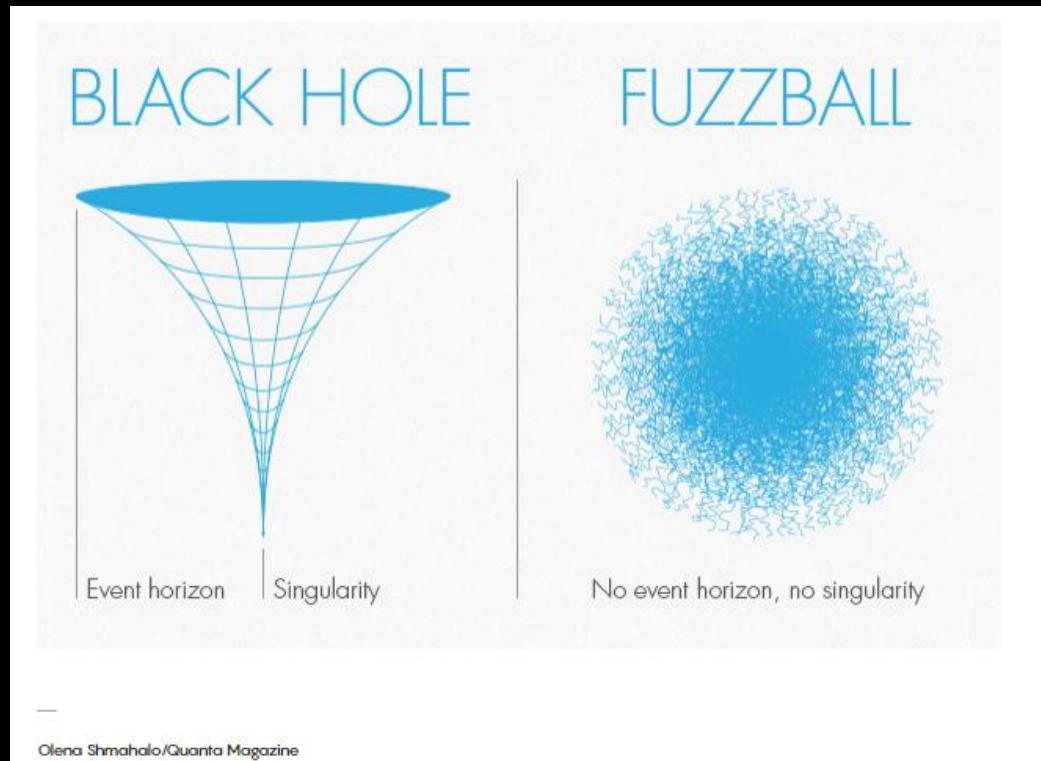


Fuzzball black holes

Fuzzy (Planck scale) string-composed event horizon

Solve information paradox

→ May not evaporate as “classic” black holes



*Accelerating strangelets via Penrose process in non-bps fuzz-balls, Bianchi, Casolino, Rizzo. Nuclear Physics B, 954:115010, 2020. ISSN 0550-3213.
doi:<https://doi.org/10.1016/j.nuclphysb.2020.115010>.*

SQM – ISS Direct Detection

ADC → Charge
TDC → Speed
Coincidence → Range

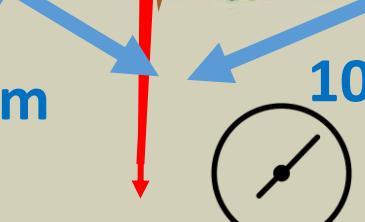
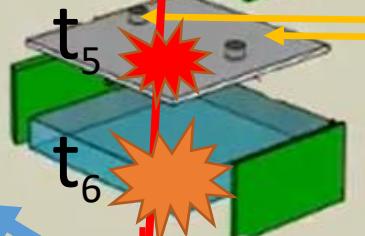
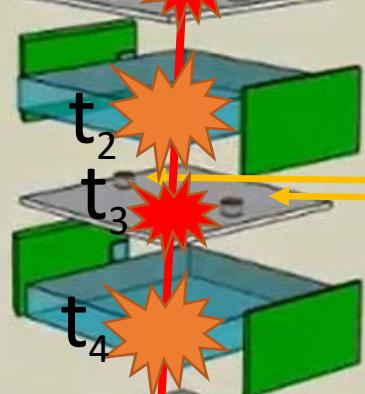
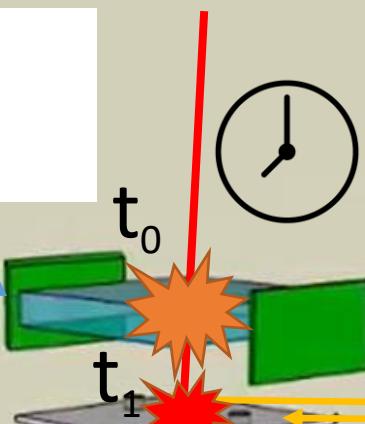
Photonic (ionization)
PhoNonic (physical hit)
Negligible background
Independent readout

SiPM (Charge readout)

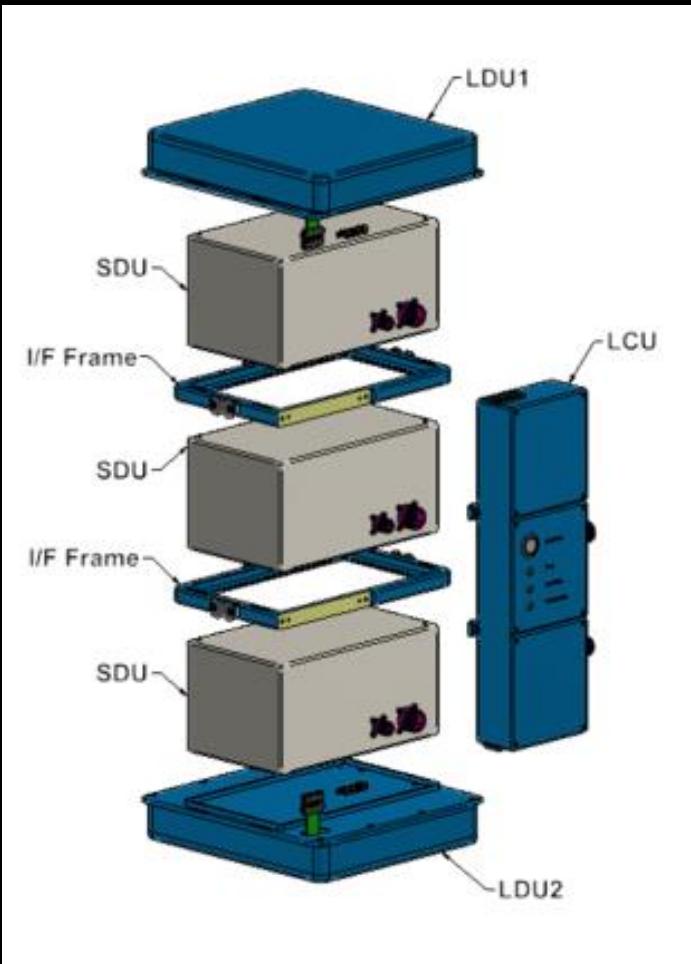
7 cm

10 cm

10 cm



Altea / Lidal → TOF system



L. Di Fino, L. Narici

Dust (local and interstellar) monitors with Piezoelectric detectors

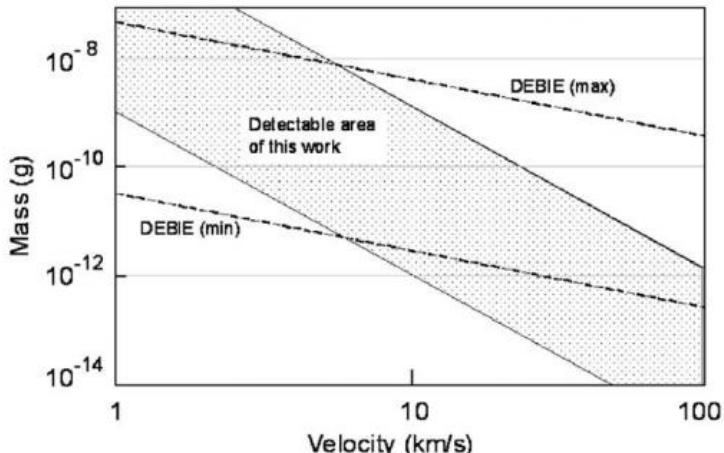


Fig. 2. Detectable conditions of the MDM and the DEBIE (ESA, PROBA-1 mission) counter (Leese et al., 1996).

Development of the Mercury dust monitor (MDM) onboard the BepiColombo mission

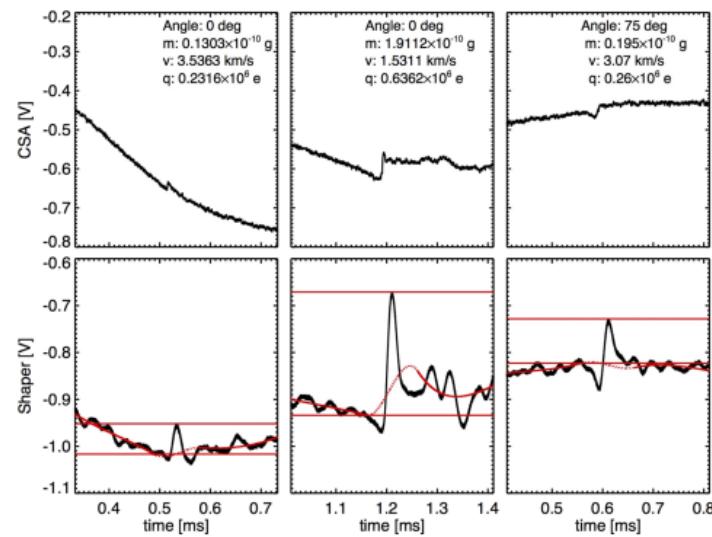


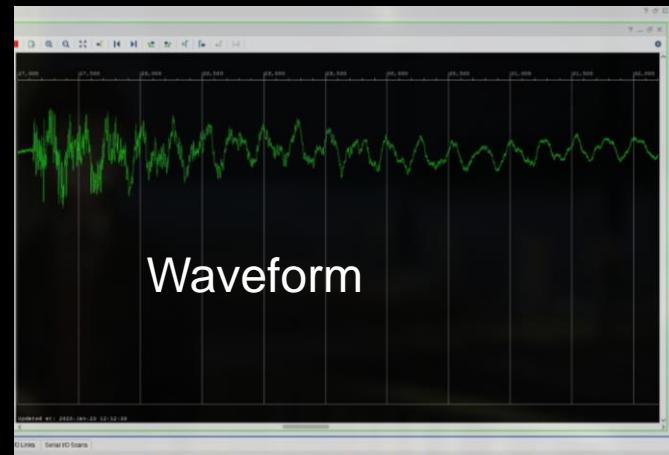
FIG. 4. CSA and shaper waveforms for three different impacts. On the left is an impact at 0° of a grain with mass of 1.3×10^{-11} g, a speed of 3.5 km/s, and a charge of 2.3×10^5 e. In the middle is an impact at 0° of a grain with mass of 1.9×10^{-10} g, a speed of 1.5 km/s, and a charge of 6.4×10^5 e. On the right is an impact at 75° of a grain with mass of 2.0×10^{-11} g, a speed of 3.1 km/s, and a charge of 2.6×10^5 e. The top row shows the raw CSA waveform, and the bottom row shows the raw shaper waveform with a quartic polynomial fit of the background piezoelectric noise with horizontal lines representing the baseline and peak signal used to calculate the signal amplitude. Acoustic ringing is observed immediately after the impact signal for larger particles, shown in the middle column, as well as larger particles, shown on the right, as well as larger particles, show a dip just before the impact signal.

Calibration of polyvinylidene fluoride based dust detectors in response to varying grain density and incidence angle

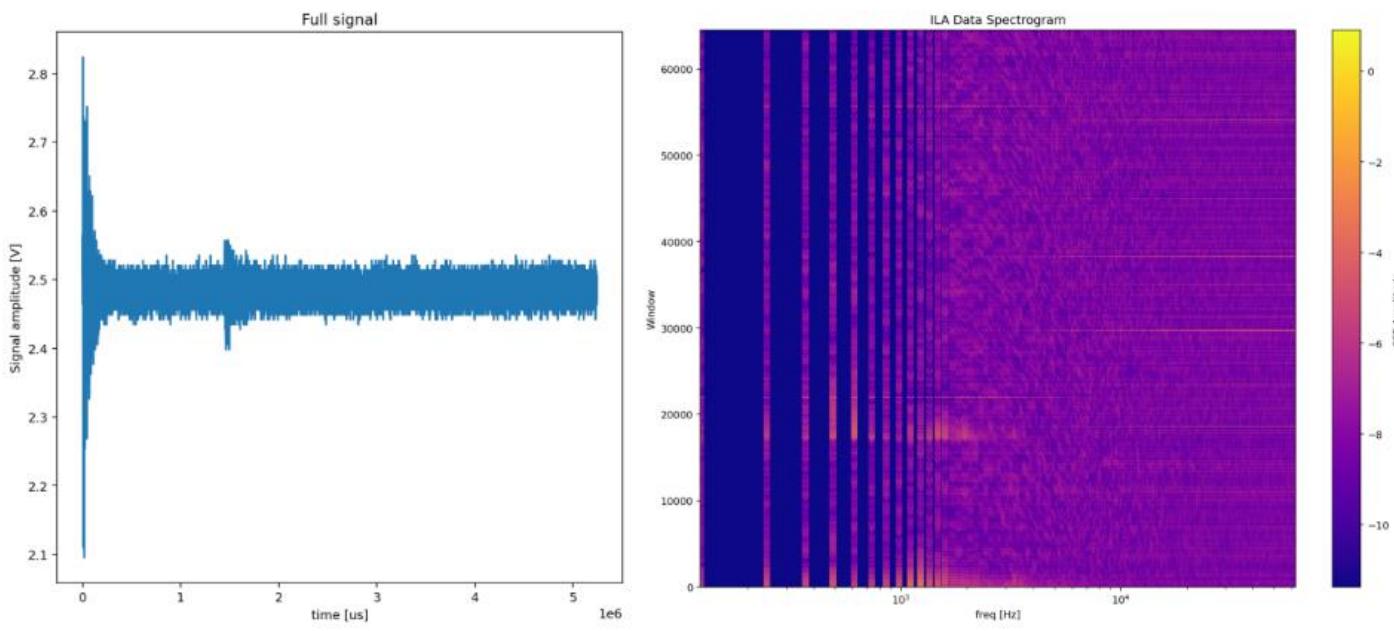
Cite as: Rev. Sci. Instrum. 91, 023307 (2020); doi: 10.1063/1.5125448
Submitted: 22 August 2019 • Accepted: 9 January 2020 •
Published Online: 4 February 2020



Piezoelectric detectors

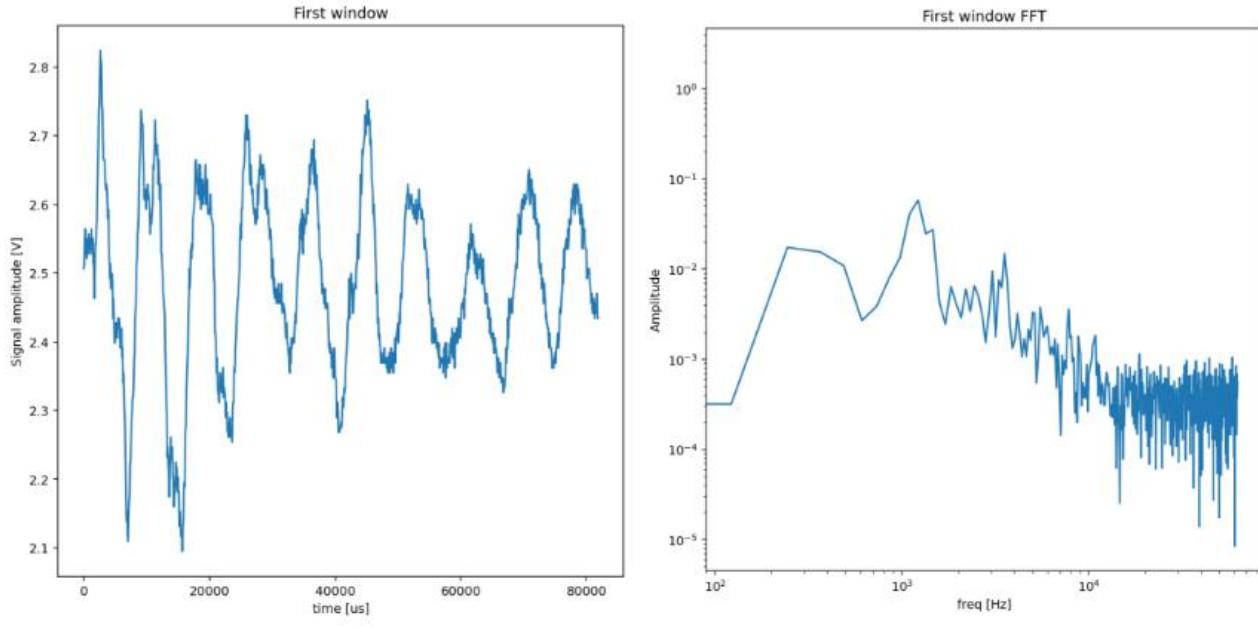


A. Marcelli



(a) Dido ball from 150 mm height response

(b) Corresponding spectrogram



(a) 1st window for Dido ball from 150 mm height

(b) Corresponding FFT

SQM-SPB3?

See talk of L. Wiencke for SBP2-SBP3



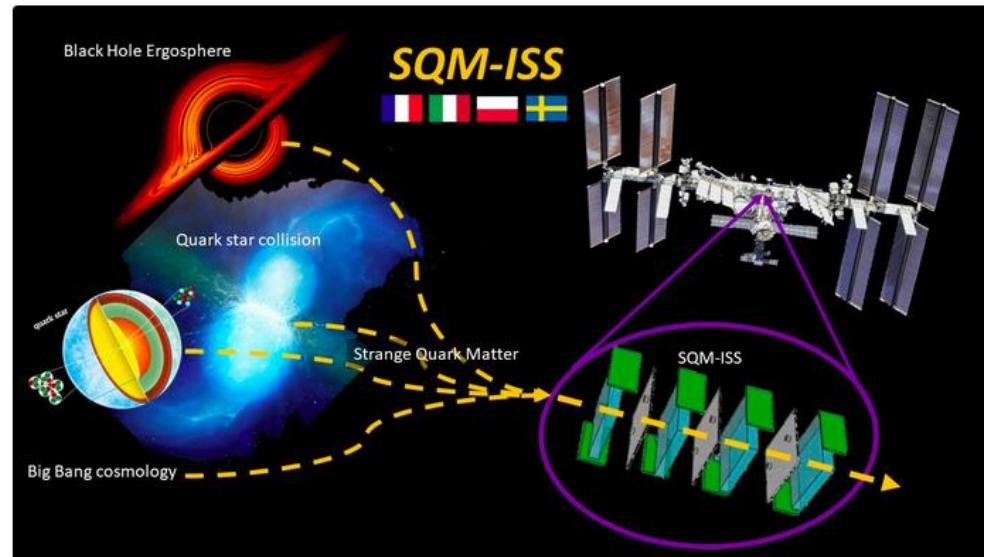
- 5-6 kg
- Compact
- Low data rate
- Charged count (Galactic, SPEs)
- Correlation with CT FT
(part of shower, ToO)



IDEA: I-2022-02839

SQM-ISS Search for Strange Quark Matter and nuclearites on board the International Space Station

Campaign: Reserve pools of Science Activities for ISS: A SciSpace Announcement of Opportunity



SELECTED

“.... It is our pleasure to inform you that your proposal, with the registration code AO-2022-ISS-I-2022-02839 and the title “SQM-ISS Search for Strange Quark Matter and nuclearites on board the International Space Station” was judged favourable by the peers and has been selected for definition. The overall scientific merit was **Excellent (90/100)**.”

Conclusion and perspectives

- ISS-SQM selected as “excellent” idea from ESA
- 2-3 years to launch
- Pre-Lab model to study properties
- Cubesat → Moon

